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April 28, 1994

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W., Room 222
Washington, D.C. 20554

Re: GEN Docket No. 90-314
Ex Parte Presentation

Dear Mr. Caton:

On April 26, 1994, representatives of Apple Computer, Inc. (Cheryl Vedoe, Sue Collins, Jackie Robinson, James Burger and Henry Goldberg) met with members of the PCS Task Force (Robert Pepper and Donald Gips) to discuss wireless computing applications in education. Copies of the attached documents were provided to Mr. Pepper and Mr. Gips; two copies are hereby submitted for the public record in accordance with 47 C.F.R. § 1.1206(b). Apple did not present any other facts or arguments that are not reflected in its written submissions in this docket.

I apologize that I was unable to file copies of these documents on the day the meeting occurred.

If there are any questions in this regard, please contact the undersigned.

Sincerely,

Mary Dent

cc: Robert Pepper
Donald Gips

Apple Education Research Series:

Effectiveness Reports

Spring 1994

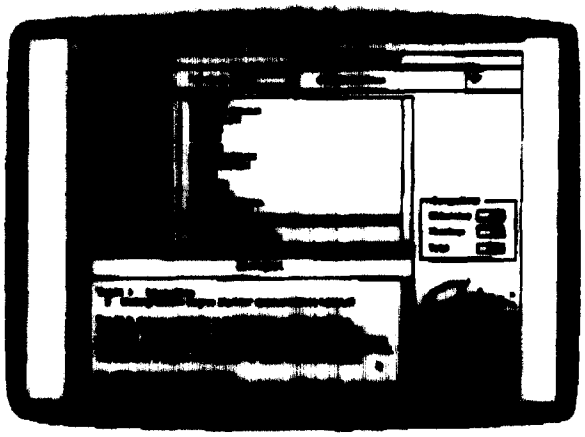
High school students use their computers to design proposals for agricultural-related businesses. One plans her own pet shop, another an interior "plantscaping" service. They also use the computer to create a resume and write both cover and follow-up letters for their job search.

Preparing Students for the Workforce

Why use computers to prepare students for the workforce?

The SCANS Report notes that the personal computer "has reconfigured the world of work as has perhaps no other invention since electricity or the assembly line" and points out that students need "enabling" skills—basic skills, thinking skills, and functional skills in the areas of systems, personal interactions, information, resources, and technology—to prepare for today's work force.

Vocationally-oriented education programs teach subjects today that didn't exist a few years ago. Desktop publishing, electronic spreadsheets, word processing, and CAD-CAM are all common to vocational and business education programs in schools. Computers motivate students, providing realistic simulations and productive tasks that match workplace requirements. Students, like workers in business and industry, use computers to manipulate and manage data—to solve problems, to build from ideas, to control technology systems, and to make presentations that help others understand.



Choices, from Careerware, helps students explore hundreds of occupations matched to their interests and educational program.

Vocational, tech prep, and business education programs can bridge the high-tech world of students' everyday lives and the increasingly technological environment of the workplace. The computer is central to both worlds; it needs to become a central part of the schools' vocationally-oriented programs, too. People entering most occupations must have basic skills in using computer application programs. Computers need to be part of systematic plans to address the transition between school and work.

What the research says:

Computers help students master the basic skills needed to participate and succeed in vocational education programs—and in the workforce.[1]

In addition to helping students develop competencies in basic skills, the experience of using technology helps prepare them to use the contemporary tools of the workplace.[2]

Effectiveness Reports

Preparing Students for the Workforce

Computer applications in vocational courses with "heavily enriched mathematics content," such as electronics, CAD, or agricultural science, help produce significant gains in mathematics competencies.[3]

Writing instruction using word processing improves the students' quality of writing as well as their attitudes toward writing.[4]

Citations for research results:

[1]Dees, A. (1990). Basic skills go high tech. *Vocational Education Journal*, 65(1), 30-33.

[2]Imel, S. (1992). Computer-assisted instruction in vocational education. Columbus, Ohio: ERIC Clearinghouse on Adult, Career, and Vocational Education. (ED 347 327)

[3]Copa, G.H., & Copa, P.M. (1992). Vocational education. In Marvin C. Alkin, (Ed.), *Encyclopedia of Educational Research* (Sixth Edition). New York: Macmillan.

[4]Scheaman, R.M. (1991). The effects of using word processing equipment in writing instruction. *Business Education Forum*, 26, 7-11.

Things to read:

Association for Supervision and Curriculum Development. (1992) Education for employment (special issue). *Educational Leadership*, 49(6).

Tommye Lou Grenn, et al. (1992). How I use computers in. . . *Vocational Education Journal*, 67(3), 25-29.

Barbara Malpiedi Kirby (1992). On the cutting edge: A review of state-of-the-art instructional technology. *Vocational Education Journal*, 67(3), 32-33; 53.

V. Wayne Klemin (1993). Multimedia and business education. *Business Education Forum*, 28, 27-30.

N. L. McCaslin & Robert M. Torres (1990). Personal computers--More than calculators and word processors! *The Agricultural Education Magazine*, 64(12), 22-23.

Rutherford, Brian (1992). Using the Macintosh computing environment to move from industrial to technology education. *School Shop/Tech Directions*, February, 20-21.

Ernest Savage (1993). Technology education: Meeting the needs of a complex society. *NASSP Bulletin*, 77(554), 41-53.

Places to call or visit:

Phil Jones, Assistant Principal, Lake Highlands High School, 9449 Church Road, Dallas, TX 75238, 214/553-4220

Ken Matheson, Superintendent, Mendocino Unified School District, P.O. Box 1154, Mendocino, CA 95460, 707/937-5868

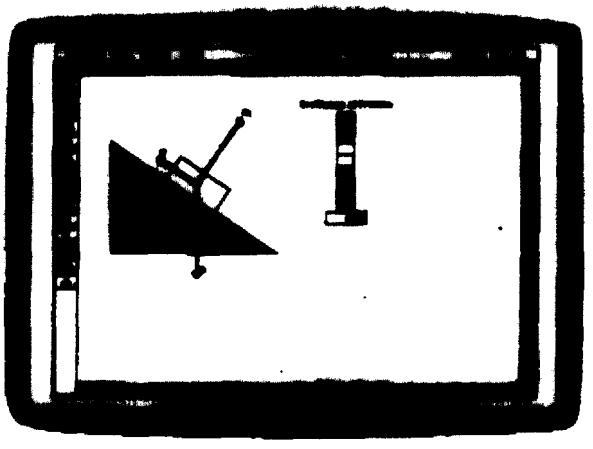
Steve Simms, Technology Teacher, West Junior High, 1309 Holly Drive, Richardson, TX 75080, 214/470-5359

After their science teacher introduces his favorite classroom tool—*Sensorfist*, a way to collect and analyze laboratory data using computer probes—students start coming in before and after school to practice their pH labs, do temperature studies, and learn to manipulate the data for class presentations.

High School Science

Why use computers in science instruction?

To reach the National Educational Goals for the Year 2000, students must master scientific problem-solving skills. And there is no better way to encourage development of these skills than through the use of technology to solve scientific problems. This approach focuses on a classroom environment that is rich in opportunities for cooperative learning; that is organized around themes, not textbook approaches to scientific disciplines; that offers an abundance of interdisciplinary, real-world problems for students to tackle; and that shifts the responsibility for learning to the student.



Interactive Physics, from Knowledge Revolution, lets students explore scientific principles by manipulating objects and their environment.

The computer is central to this way of teaching and learning. Using multimedia applications, students have access to vast visual and audio collections of scientific data—pictures to help explain phenomena, to use for presentations, and to help students who learn best visually. Microcomputer-based laboratories can measure time, temperature, voltage, pH, light intensity, and force. And students can take frequent and reliable measurements without worrying about the calculation necessary to portray the data—and they can manipulate that data, asking the "what-if" questions that practicing scientists ask.

What the research says:

When the computer is used to do what couldn't easily be done without computers, greater achievement gains are seen and attitudes toward science improve.[1]

Students learn more efficiently when they can watch the science event and its real-time graphic representation simultaneously. Just using computers for graphing seems to aid students' understanding of science concepts and removes the drudgery of creating the physical graph.[2]

Computerized simulation expands classroom inquiry and improves learning. Working with simulations encourages the students to think hypothetically and to use complex strategies with variables.[3]

Learning-disabled (LD) students using computer simulations score significantly higher than did traditionally taught students—both LD and non-LD—on recall of basic information and problem-solving skills.[4]

Effectiveness Reports

When working with complex models, students using the computer seem able to grasp and apply systems thinking to analysis and even transfer the concepts from one science area to another.[5]

Computer modeling and visualization in physics allow advanced science students to spend more time in active scientific inquiry.[6]

Citations for research results:

[1]Lewis, D.R. & Good, R. (1988). The nature and use of prediction skills in a biological computer simulation. *Journal of Research in Science Teaching, 2*(5), 335-360.

[2]Russell, H. (1987). The effect of real-time laboratory graphing on learning graphic representations of distance and velocity. *Journal of Research in Science Teaching, 24*(4), 385-395. Also, see Linn, Marcia C. Layman, J.W. & Nachmias, R. (1987). Cognitive consequences of microcomputer-based laboratories: Graphing skills development. *Contemporary Educational Psychology, 12*, 244-253.

[3]Mintz, R. (1993). Computerized simulation as an inquiry tool. *School Science and Mathematics, 93*(2), 76-80. Also, see Rivers, R. and Vockell, E. (1987). Computer simulations to stimulate scientific problem solving. *Journal of Research in Science Teaching, 24*(5), 403-415.

[4]Woodward, J. Carnine, D., & Gersten, R. (1988). Teaching problem-solving through computer simulations. *American Educational Research Journal, 25*(1), 72-86.

[5]Mandinach, E.B., et al. (1988). The impact of the systems thinking approach on teaching and learning activities. Educational Testing Service Report. (ED 305 928) Also, see Mandinach, E.B. (1988). *The cognitive effects of simulation modeling software and systems thinking and learning and achievement*. Paper presented at the American Education Research Association Convention.

[6]Shore, L.S., et al. (1992). Learning fractals by "doing science": Applying cognitive apprenticeship strategies to curriculum design and instruction. *Interactive Learning Environments, 2*(3&4), 205-226.

Things to read:

Leslie Elser (1992). Multimedia science programs: Moving science education beyond the textbook. *Technology and Learning, 12*(6), 16-33.

Randolf Tobias (1992). Math and science education for African-American youth: A curriculum challenge. *NASSP Bulletin, 76*(546), 42-55.

Ronald Aust (1991). Computer networking strategies for building collaboration among science educators. (ED 347 058)

John LeBaron & Rebecca Warshawsky (1991). Satellite teleconferencing between Massachusetts and Germany. *Educational Leadership, 48*(7), 61-64.

Places to call or visit:

Jim Nasworthy, Physics Teacher, John Biggerstaff, Math Teacher, Lee's Summit High School, 400 East Blue Parkway, Lee's Summit, MO 64063, 816/524-7151

Ken Schnobrich, Science Department Chairperson, Clarence Senior High School, 9625 Main Street, Clarence, NY 14031, 716/759-8311

Gene Nelson, Science Teacher, Bullard High School, 5445 North Palm, Fresno, CA 93704, 209/441-3966

Mike Froning, Faculty Chair, Alabama School of Fine Arts, 700 18th Street North, Birmingham, AL 35203, 205/328-3143

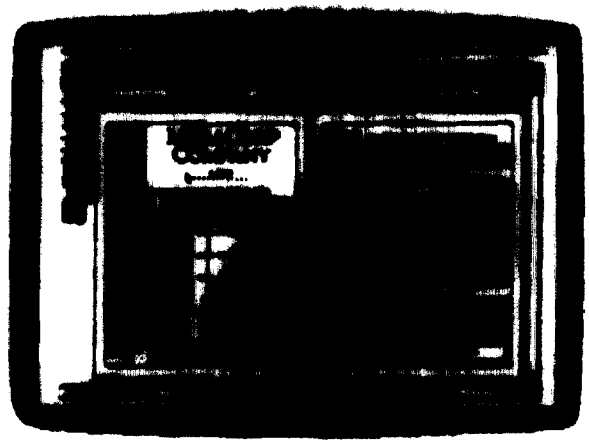
To help inspire at-risk students to write, a high school teacher begins with an exercise using *SimCity*. First, students create a city in which half the population is poor and the other half is wealthy. Using this imaginary city as background, students create characters, develop a plot, and write short stories.

High School Writing

Why use computers for high school writing instruction?

At the secondary school level, writing connects all subjects. Writing in the subject areas helps students improve their critical thinking, which, for any course, means restructuring ideas, expressing them, and truly understanding them. This process involves a student in a collaboration that includes him or herself, other writers, and the teacher.

The writing process requires motivation. Teachers find the computer the ideal tool to increase student motivation and to help students make connections among the subject areas. The computer turns the high school classroom into a learning environment where communication is accessible. Authentic writing—writing for a real audience—dramatically increases the motivation of low achievers and is readily accomplished using telecommunications. Tools for idea mapping, desktop publishing programs, and reference materials help student writers become more creative and proficient, willing to develop and express their ideas with pride and confidence.



ClarisWorks, from Claris Corporation, lets students combine graphics with text to produce professional-looking reports.

What the research says:

When students use word processing to write, there is a significant improvement in their attitude toward self, teachers, and writing.[1]

Low-achieving writers benefit from participation in telecommunications-based writing projects in which they are intrinsically motivated in a real communications environment.[2]

Urban LEP students improve their writing by using word processing (and become more positive about school and about writing). Support from word processing includes: overcoming illegible handwriting, conferencing about assignments, extending the length of assigned writing, overcoming fear of errors, and encouraging student collaboration.[3]

Reviews of the research on the effects of word processing indicate that there is an increase in revisions, fewer mistakes, and more correction of them. And when word processing use is combined with an effective teaching model, students achieve at a higher level than those not using a word processor.[4]

Effectiveness Reports

High School Writing

Studies show significant performance differences between students using computers and those writing essays by hand. Students who use computers receive higher performance scores and higher grades on their essays. Computer essays contain fewer punctuation errors, and have a greater average sentence length and a greater number of complex sentences.[5]

Citations for research results:

[1]Kurth, R. (1987). Using word processing to enhance revision strategies during student writing activities. *Educational Technology*, *27*(1), 13-19.

[2]Spaulding, C. & Laise, D. (1991-1992). Interactive effects of computer network and student characteristics on students' writing and collaborating. Cited in Riel, M. (1992). Approaching the study of networks. *The Computer Teacher*, *19*(4), 7-9, 52.

[3]Silver, N.W. & Repa, T.J. (1993). The effect of word processing on the quality of writing and self esteem of secondary school English-as-a-second-language students: Writing without censure. *Journal of Educational Computing Research*, *9*(2), 265-283.

[4]Snyder, I. (1993). Writing with word processors: A research overview. *Educational Research*, *35*(1), 49-65.

[5]Robinson-Staveley, K. & Cooper, J. (1990). The use of computers for writing: effects on an English composition class. *Journal of Educational Research*, *6*(1), 41-48.

Things to read:

B.G. Erickson (1989). Revision for the restless: Peer editing for Macintosh. *The Computer Teacher*, *17*(1), 54-55.

Peggy Anderson (1993). Connecting with "the real world." *Momentum*, 72-73.

Sarah Schrire (1993). The computer, the class and the English teacher. *English Teachers' Journal*, *46*, 21-23.

Places to call or visit:

Wayne Robinson, Principal, Sandy Creek High School, 360 Jenkins Road, Tyrone, GA 30290, 404/969-2842

Claron Hanefeld, Technology Coordinator, East Allen County Schools, 1000 Prospect Avenue, New Haven, IN 46774, 219/493-3761

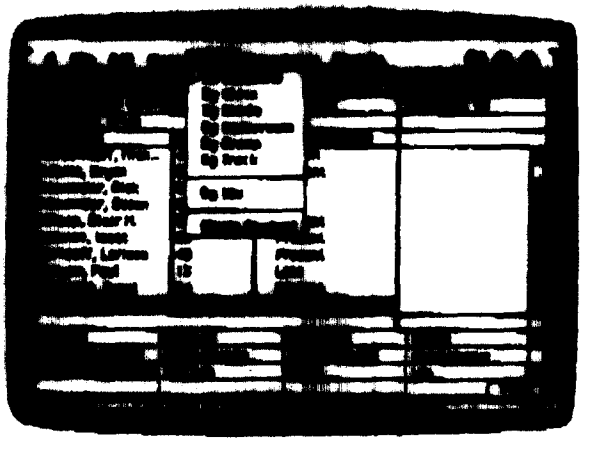
Middle school teachers, administrators, and professional staff use their PowerBook computers to make record keeping easy and increase productivity. An unexpected, but powerful, outcome is increased collaboration.

Management and Administration

Why use computer-based management tools?

Principals and other school administrators have enormous responsibilities to communicate with teachers, students, and parents; find and analyze information; manage people; and administer discipline. Technology helps school leaders accomplish these tasks with greater efficiency and productivity.

Computer networks, electronic mail, presentation software, desktop publishing, and computer databases are all components of technology that make a school administrator more effective in accomplishing his or her everyday tasks. For instance, local telephone lines allow meetings, workshops, and conferences to be held over a network, eliminating the need for travel and time away from school. Electronic mail allows for communicating with staff and parents, removing the boundaries of time and place. And powerful desktop publishing capabilities permit school administrators to make professional presentations to parents and colleagues.



Administrators can analyze attendance in a variety of ways with Chancery's Mac School Student Information System.

What the research says:

Providing computers and printers (and training) to all teachers and school administrators, for at home or in school use, increases both administrative productivity and feelings of professionalism.[1]

Principals using technology for administrative purposes in their schools report an increase in autonomy from district office control and the ability to be more personally productive using word processing.[2]

Principals who learn about both administrative and educational applications of technology feel more confident in dealing with staff requests and purchase decisions.[3]

Establishing a "homework hotline" using telecommunications increased homework

Effectiveness Reports

time by two hours/student/week—and students continued getting schoolwork from the system during the summer.[4]

Elementary teachers provided with laptop computers tend to increase their use of the computers for administrative applications, especially record keeping and grading.[5]

Teachers with laptop computers report significant pedagogical changes: increases in the amount of inquiry-oriented instruction and project-based activities, increased collaboration with teachers, and more communication with students.[6]

Citations for research results:

[1]Rockman, S., Pershing, J. & Ware, W. (1992). Productivity, professionalism, and empowerment. Indianapolis: Indiana Department of Education.

[2]Cannings, T.R. and Polin, L. (1987). The computer as an administrative tool: A survey of 30 high schools. In A. Bank and R. Williams (Eds.), *Information systems and school improvement: Inventing the future*. New York: Teachers College Press, 39-56.

[3]Rockman, S. and Sloan, K.R. (1993). A program that works: Indiana's principals' technology leadership training program. Indianapolis: Indiana Department of Education.

[4]Mountain, L. (1992-1993). Doing homework on a telecommunications network. *Journal of Educational Technology Systems*, *21*(2), 103-107.

[5]Weast, J.D., Parry, J. and Peterson, T. (1993). Empowering middle school teachers with portable computers. *ERS Spectrum*, *11*(3), 22-26.

[6]McMillan, K. and Honey, M. (1993). Year one of Project Pulse: Pupils using laptops in science and English. *Technical Report No. 26*. New York: Center for Technology in Education. (ED 358 822)

Things to read:

Judy J. Harris (1995). Computer use in elementary schools: An update. *Principal*, *72*(3), 50-51.

Thomas F. Kelly (1991). Effective schools and computers. *Principal*, *70*(3), 53-54.

Peter H. Lewis (1991). The Technology of Tomorrow. *Principal*, *71*(2), 6-7.

Lynne Schrum (1992). What is distance education? *Principal*, *71*(3), 56-57.

K-12 computer networking, *ERIC Review*, *2*(3) Winter 1993. (ED 355 940)

Dan H. Wishnietsky (1991). Using electronic mail in an educational setting: Bloomington, IN: Phi Delta Kappa *Fastback*, 16.

Places to call or visit:

Tom Petersen, Library Media Supervisor, Sioux Falls Public Schools, 1116 West Ninth Street, Sioux Falls, SD 57104, 605/331-7951

Martha Lyle, Principal, L.D. McArthur Elementary, 330 East Ten Mile Road, Pensacola, FL 32534, 904/484-5115

Eileen Steele, K-12 Computer Coordinator, Lafayette School Corporation, 2300 Cason Street, Lafayette, IN 47904, 317/449-3230

Ken Matheson, Superintendent, Mendocino Unified School District, P.O. Box 1154, Mendocino, CA 95460, 707/937-5868

History students use computers, videodiscs, and a variety of software to study the Middle Ages. After viewing 14 different castles on the *Salamandre* videodisc, they choose a favorite, then explore the *National Gallery of Art* videodisc to find art of the same period.

Middle School Social Studies

Why use computers in teaching social studies?

Social studies education should stimulate high levels of thinking and analysis. Computers and other technologies provide powerful tools for learning concepts, testing generalizations, solving problems, and processing information in order to make decisions. Students can use the technology to brainstorm ideas, test hypotheses, outline their thoughts, organize their ideas, and connect one idea to the next. With technology, students can work together, sharing thoughts and resources as they collect data, solve problems, and develop new ideas. Students can use multimedia to create exciting, informative presentations that engage their classmates.

Middle school students are motivated and challenged by computers and related technologies. Schools can enhance these interests by providing new instructional approaches that use the computer—from simulations of historical events to "What-if?" questions of national databases, from geography games to powerful research and presentation tools. In the social studies, technology can help make connections to the real world, provide access to enormous amounts of information, and encourage collaborative work.

What the research says:

The computer can be a powerful tool for the delivery of critical-thinking and problem-solving activities in the social studies classroom. At the same time, the computer offers the opportunity for successful collaborative learning.[1]

Computers help students organize and manipulate information and improve performance in problem solving.[2]

Students can use computers to graph, help interpret information, and apply that knowledge in social studies.[3]

Students using computers in a history class demonstrated increased motivation and recall and took less time to complete the unit.[4]

Citations for research results:

[1] Repman, J. (1993). Collaborative, computer-based learning: Cognitive and affective outcomes. *Journal of Educational Computing Research, 9*(7), 149-163.

[2] White, C.S. (1987). Developing information-processing skills through structured activities with a computerized file-management program. *Journal of Educational Computing Research, 3*(3), 355-375.

[3] Jackson, D., Berger, C. and Edwards, B. J. (1992). Computer-assisted thinking tools: Problem solving in graphical data analysis. *Journal of Educational Computing Research, 8*(1), 43-67.

Effectiveness Reports

[4]Yang, Y.C., (1991-1992). The effects of media on motivation and content recall: Comparison of computer and print based instruction. *Journal of Educational Technology Systems, 20*, 95-105.

Things to read:

James Barth (1990). Methods of instruction in social studies education. Washington, D.C.: University Press of America.

Howard Budin, Robert Taylor & Diane Kendall (1987). Computers and social studies: Trends and directions. *The Social Studies*, 78(1), 7-12.

Michael W. Reed & Gwendolyn S. Rosenbluth (1992). The effect of HyperCard programming on knowledge construction and interrelatedness of humanities-based information. (ED 355 908)

Charles S. White (1991). Technology and social studies education: Potentials and a prognosis. *NASSP Bulletin*, 75(531), 33-41.

Juliette Avots (1993). Technology as a bridge. *Educational Leadership*, 50(7), 83-84.

Bruce Watson (1990). The wired classroom: American education goes on-line. *Phi Delta Kappan*, 72(2), 109-112.

Paula Kay Montgomery (1992). Integrating Library, Media, Research, and Information Skills. *Phi Delta Kappan*, 73(7), 529-532.

Timothy Tyler (1992). A School with Its Own TV Station. *Principal*, 72(4), 51-52.

Places to call or visit:

Camille Barr, Principal, Brown Barge Middle School, 151 East Fairfield Drive, Pensacola, FL 32503, 904/444-2700

Mary Anne Charron, Principal, Trickum Middle School, 948 Cole Drive, Lilburn, GA 30247-5498, 404/921-2705

Claron Hanefeld, Technology Coordinator, East Allen County Schools, 1000 Prospect Avenue, New Haven, IN 46774, 219/493-3761

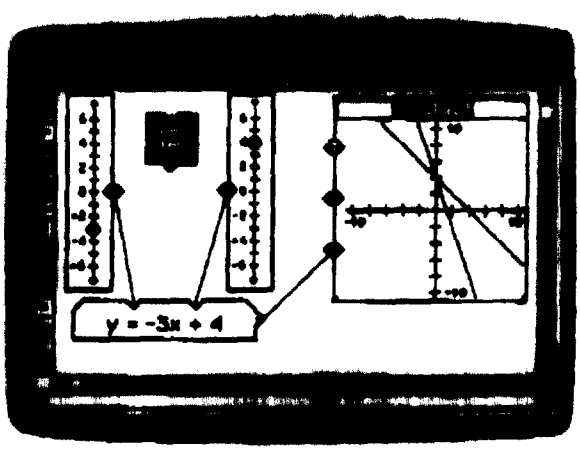
Ninth-graders create multimedia science presentations for parents and local scientists and use half the time to explain where they locate information, how they organize it, and why they make the information choices they do.

Middle School Science and Mathematics

Why use computers for middle school science?

An inquiry approach to middle school science and mathematics is strongly endorsed by both NCTM and NSTA. In middle schools, students benefit from collaborative learning and the opportunity to explore and try out alternatives. They need content and processes connected to the world around them. The computer can play a vital role in making science and mathematics real, dynamic, and engaging for students.

Technology allows for the "doing" of science, providing hands-on experiences for students. There are a growing number of science learning opportunities on classroom networks, as part of telecommunications services, and in the form of microcomputer-based laboratories. Simulation software allows students to interact with environments otherwise unavailable to them.



Math Connections: Algebra I, *from Sunburst/WINGS for learning, lets students work with on-screen "objects" that display variables, functions, and graphs.*

Innovative software encourages students to apply math skills to real-world problems in order to gain a deeper understanding of the concepts. Technology helps them make connections, analyze ideas, and develop conceptual frameworks for thinking and problem solving. They can do real science, apply mathematics, and share their findings with others.

What the research says:

Microcomputer-based laboratory experiments improve the knowledge of science concepts and processes, and encourage the application of multiple modalities in authentic science experiences.[1]

Using computers for performing graphing functions seems to aid students' understanding of science concepts and removes the drudgery of creating the physical graph.[2]

Students who used computers to create computational models of scientific processes dealt with more complex problems than those without modeling software.[3]

Computer tools in science help students understand and master high-level science concepts, working through a progression of conceptual levels.[4]

Effectiveness Reports

Students who use computers for math problem solving improve interpersonal relationships and increase creativity.[5]

Students spend more time analyzing and interpreting data when they use computers in an integrated, problem-based curriculum.[6]

Citations for research results:

[1] Summers, M., Solomon, J., Bevan, R., Frost, A., Reynolds, H., Zimmerman, C., (1991). Can pupils learn through their own movement? A study of the use of a motion sensor interface. *Physics Education*, *26*(6), 345-349. Also, see Stein, J.S., Nachmias, R., and Friedler., Y. (1990). An experimental comparison of two science laboratory environments: Traditional and microcomputer-based. *Journal of Educational Computing Research*. *6*(2), 183-202.

[2] Mokros, J. & Tinker, R.F. (1987). The impact of microcomputer-based labs on children's ability to interpret graphs. *Journal of Research in Science Teaching*, *24*(4), 369-383. Also see, Linn, M. & Songer, N.B. (1991). How do students' views of science influence knowledge integration? *Journal of Research in Science Teaching*, *28*(9), 761-784.

[3] Miller, R. et al. (1993). Educational tools for computational modelling. *Computers and Education*, *21*(3), 205-261.

[4] Linn, M. Songer, N.B., Lewis, E.L., & Stern, J. Using technology to teach thermodynamics: Achieving integrated understanding. In D.L. Ferguson (Ed), *Advanced technologies in the teaching of mathematics and science*. Berlin: Springer-Verlag, in press. Also, see Eylon, B-S., & Linn, M. (1991). *Models and integration activities in science education: Designing intelligent learning environments*. Norwood NJ Ablex Publishing Co.

[5] Niess, M. (1992). Winds of Change. *The Computing Teacher*, *19*(6), 32-35.

[6] Mevarech, Z. & Kramarski, B. (1992). How and how much can cooperative logo environments enhance creativity and social relationships? *Learning and Instruction*, *2*, 259-274.

Things to read:

John LeBaron & Rebecca Warshawsky (1991). Satellite teleconferencing between Massachusetts and Germany. *Educational Leadership*, *48*(7), 61-64.

Randolf Tobias (1992). Math and science education for African-American youth: A curriculum challenge. *NASSP Bulletin*, *76*(546), 42-55.

J. McFaul (1991). JEdI project helps bring school science down to earth. *Computer Digest*, *6*(7), 9.

C. L. Anderson (1990). Strategies for introducing databases into science. *Journal of Computers in Mathematics and Science Teaching*, *9*(2), 11-22.

Jose Manuel Yubar, et al. The computer as a tool for curriculum development in the classroom. *Educational Media International*, *30*(3) 1993.

Places to call or visit:

Ruthie Blankenbaker, Technology & Curriculum Coordinator, Park Tudor School, 7200 North College Avenue, Indianapolis, IN 46240, 317/254-2716

Steve Simms, Technology Teacher, West Junior High, 1309 Holly Drive, Richardson, TX 75080, 214/470-5359

Middle school students create an interactive report about Greek mythology. This "yearbook" begins with a picture showing students dressed as gods or goddesses. A click on any face displays information about that character.

Middle School Language Arts

Why use computers in language arts?

The best way to learn language is to create it. A language arts classroom should be a work center where students create professional-looking language productions, from prose to poetry to plays. And they should work together—collaborative learning is especially effective at the middle school level. Computer networks link writers with one another, providing the real audience adolescent learners need, along with peer interaction for revision and conferencing. Through the network, students share comments or collaborate on the same document from computers in different places. Telecommunications extends the network to others around the world. In these ways, technology fosters exploration and production with words and ideas.

Reading is also an important part of the middle school language arts curriculum. Technology can support the development of comprehension skills by posing questions and providing "story support." Telecommunications and multimedia technologies create functional language-learning environments where reading skills are developed in the context of accomplishing a task. Computer programs surround and support the act of reading with access to hypertext, graphics, sound, music, animation, and video. Click on a word and find out how it sounds, or what it means, in English or in Spanish. The computer can even record a child's oral reading and play it back for his own analysis. Technology allows a fully integrated approach to the language arts.

What the research says:

Reviews of the research have found that when word processing use is combined with an effective teaching model, students achieve at a higher level than those not using a word processor.[1]

Studies of revision on the word processor point to an increase in the frequency of revision, fewer mistakes, and more corrections.[1]

Remedial reading students using computer reading games to develop and reinforce reading comprehension skills showed significant gains on reading achievement and improved attitudes toward reading.[2]

When measured holistically, students using laptop computers to keep journals, write stories, and complete assignments in science and English classes showed marked improvement in their ability to communicate persuasively, organize ideas logically, and use a broad vocabulary effectively.[3]

Students participating in writing activities over telecommunications show dramatic improvements in writing quality and attitudes toward writing, and often improve their reading comprehension and vocabulary, as well.[4]

Effectiveness Reports

Middle School Language Arts

Middle school students using computers improve the quality of their writing and learn knowledge-transforming and text-construction strategies. More experienced writers improve their existing competencies in creating narrative.[5]

Students in an inquiry-based curriculum who used a variety of technologies, including CD-ROM, videodiscs, and computers to organize, plan, and collect information and write reports, acquired significant amounts of content knowledge and developed a positive self-image.[6]

A computer-managed spelling instruction program improved seventh-grade spelling performance significantly.[7]

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Places to call or visit:

Claron Hanefeld, Technology Coordinator, East Allen County Schools, 1000 Prospect Avenue, New Haven, IN 46774, 219/493-3761

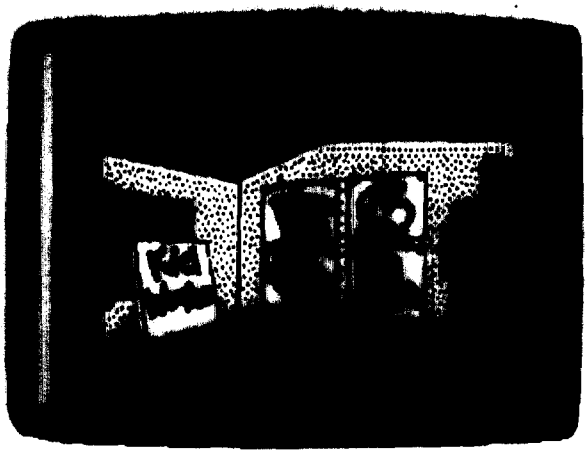
Joel Orleck, Computer Coordinator, Meigs Magnet School, 713 Ramsey Street, Nashville, TN 37206, 615/244-9261

In a kindergarten class, students create small books on the computer. One writing project that helps students recognize both numbers and letters involves making a "phone book" that collects classmates' names and numbers.

Elementary School Language Arts

Why use computers for language acquisition?

The earliest writers, kindergartners and first-graders, use language to tell stories and illustrate them—wanting to communicate their own experiences and ideas. When writing or listening to a story, or working on projects using paint or graphics programs, children are also using spelling and vocabulary functionally. And as children use words, they begin to read.



Davidson's Kid Works 2 *provides an exploratory environment for writing, drawing, and listening.*

Children write freely on the word processor. Some researchers find that children's word processing is more like speech than other writing, and children choose to spend more time on language acquisition in classrooms with a word processor. When children are motivated by technology, learning is fun and students become actively involved in the learning process.

The opportunity to develop language skills occurs when listening, reading, speaking, and writing skills are combined in real tasks. Language arts projects, such as having students use computers to develop a newspaper to be shared with parents and other students, can dramatically improve language mechanics while, at the same time, enhance attitudes toward writing and other language skills.

What the research says:

Children quickly learn to use word processing software and often do better writing than with pencil and paper.[1]

Using word processing results in fewer grammar, punctuation, and capitalization errors, especially among students with low abilities.[2]

Authentic writing with computers is an effective way of learning language mechanics. When combined with the use of telecommunications, such as a cooperative development project, improvements show up on both holistic assessments and standardized tests.[3]

When children use a computer to study spelling, they are more engaged and, as a result, achieve higher spelling scores.[4]

Effectiveness Reports

When teachers learn about computers, this new knowledge helps their students' writing improve, mainly because they give students more opportunity to write on the computer.[5]

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Places to call or visit:

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Liz Whitaker, Coordinator Instructional Technology, Drachman Elementary School, 549 S. Convent Ave., Tucson, AZ 85701, 602/798-2735

Sandy Andrews, Assistant Principal, Lake Wylie Elementary School, 13620 Erwin Road, Charlotte, NC 28273, 704/543-3680

Cynthia Cavanagh, Coordinator of Educational Technology, William Seach Elementary School, 770 Middle Street, Weymouth, MA 02188, 617/335-7589

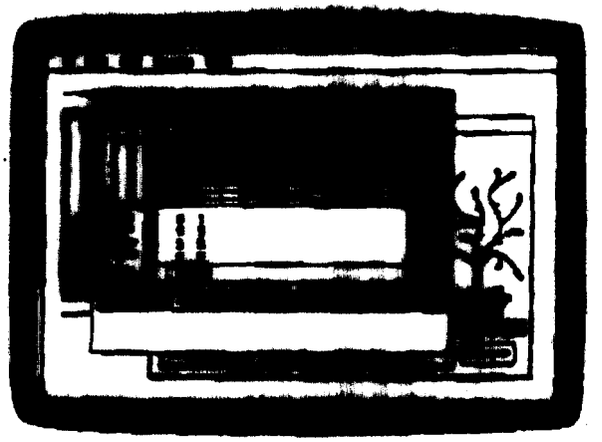
Using images from a biology videodisc, fourth-graders learn about plants and animals in the rain forest. Then, by connecting videodisc images to their own text, they create an interactive report for their classmates to read.

Elementary Science and Mathematics

Why use computers for elementary science and mathematics?

Children learn by doing, and the computer can play a vital role in making science and mathematics dynamic and engaging for students. Software designed for the elementary grades can be used effectively to teach everything from colors and shapes to the most complex science and math skills. These programs—which build on a child's natural tendency to play—focus on problem solving, reasoning, and communications.

In science, computers help make the subject matter real and accessible to children. Using computer links to telecommunications networks, students in different parts of the world can participate in projects in which they compare the length of shadows cast by a one-meter stick at different latitudes or calculate the Earth's circumference. In mathematics, students are encouraged to apply math skills to real-world problems in order to gain a deeper understanding of the concepts. Technology helps students make connections, analyze ideas, and develop conceptual frameworks for thinking and problem solving. They do real science, apply mathematics, and share their findings with others.



Botanical Gardens, *from Sunburst/WINGS for learning, lets students control many variables in simple experiments.*

Technology gives students a chance to be in control, and allows them to do things they once only read about in textbooks and workbooks.

What the research says:

Computers help elementary students of all ability levels to learn science content and to increase their logical thinking and problem-solving skills.[1]

Students show greater achievement on standardized tests after using computers for math problem solving.[2]

Telecommunications projects in science help students develop both specific science concepts and global awareness while using computer tools.[3]

Students working collaboratively to explore science concepts are effective and successful when they use a local-area network.[4]

Effectiveness Reports

Elementary Science and Mathematics

Children can use a computer-based manipulative math environment that provides more control and flexibility than hands-on materials, helping to integrate objects and symbols in a visual approach where real manipulatives are not feasible.[5]

Children using computers in mathematics are more independent learners and prefer learning on computers to learning with worksheets or precision teaching.[6]

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Places to call or visit:

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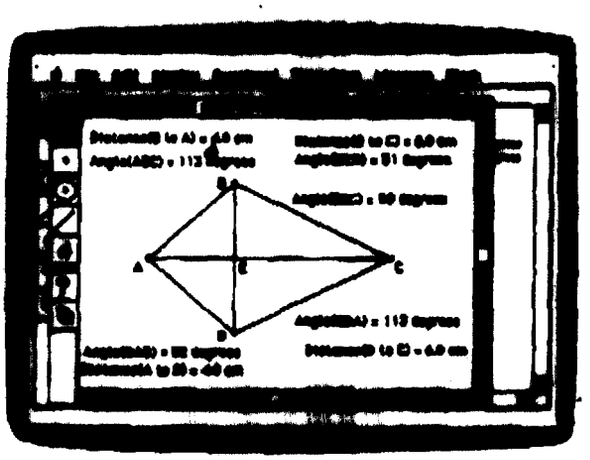
Keith Hanson, Science & Technology Resource Teacher, Franklin Park Magnet School, 2323 Ford Street, Fort Myers, FL 33916, 813/332-1750

High school students in calculus and algebra classes demonstrate their understanding of math by writing papers explaining mathematical concepts in real-world situations, using *Mathematica* to execute the examples they've created.

High School Mathematics

Why use computers in high school mathematics instruction?

As a tool in mathematics classrooms, the computer helps students understand abstract concepts by making them visual and manipulable. Students can own complex ideas by manipulating algebraic formulas and constructing geometric figures. They can study phenomena, not merely techniques. Students become active learners: they identify "interesting" behavior, explore the conditions under which it occurs, analyse their observations, and interpret their results. Students can *do* mathematics and be engaged in creative problem solving.



Students can manipulate the characteristics of geometric shapes and ask "What-if" questions using The Geometer's Sketchpad *from Key Curriculum Press.*

Technology-rich curricula reduce the time students routinely devote to practicing skills and manipulating symbols out of context. With simulations and models in geometry (or, for that matter, in algebra, trigonometry, and calculus), students can pursue questions of why, when, how, and "What-if?". As the National Council of Teachers of Mathematics notes, "The new technology has changed the very nature of the problems important to mathematics and the methods mathematicians use to investigate them."

What the research shows:

Students who use computers in math have more positive attitudes about themselves as mathematicians and about math in general, and show significant gains in problem-solving ability and content knowledge.[1]

Computer software that encourages student exploration supports instruction that increases students' understanding of mathematics principles.[2]

Students who work in small groups on geometry problems showed improvement on higher-level problem solving and applying math applications; they also received significantly higher scores on standardized final exams.[3]

Effectiveness Reports

High School Mathematics

Students using computers for algebra did significantly better on a test of knowledge than did a group taught by traditional methods. The computer group also retained more of the information and scored significantly higher on measures of transfer to other areas of mathematics.[4]

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Mary Kim Prichard (1995). Mathematical iteration through computer programming. *The Mathematics Teacher*, *88*(2), 150-156.

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Stephen S. Willoughby (1991). Mathematics. *Educational Leadership*, *48*(6), 75-76.

Places to call or visit:

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Mike Proning, Faculty Chair, Alabama School of Fine Arts, 700 18th Street North, Birmingham, AL 35203, 205/328-3143

Wayne Robinson, Principal, Sandy Creek High School, 360 Jenkins Road, Tyrone, GA 30290, 404/969-2842

Since its inception in 1985, the Apple Classrooms of Tomorrow (ACOT) project has established partnerships with school districts and researchers across the United States.

In the 1990 ACOT research report summarized here, Jane L. David, Ph.D., discusses the evolution of ACOT and suggests findings that might influence the success of other education-business partnerships. To get the complete report, see the information section at the end of this summary.

Partnerships for Change

Evolution of ACOT Partnerships

ACOT began as an experiment about the effects of computers on education, asking the question: What happens to teaching and learning when every teacher, and every student, has two computers—one at school and one at home? To answer it, Apple set up research partnerships with several school districts.

The partnerships began as straightforward relationships between Apple and the school districts. Apple provided equipment and technical support, and the districts supplied teachers and students willing to experiment with technology, report on their experiences, and be available for study by Apple and Apple's consultants. As the participants gained more experience, the nature of the partnerships changed, their number grew, and the researchers' initial assumptions were revised.

Initially, for example, Apple's concept of technology access involved providing each student with a computer at home and at school. But the realities of the classroom, and the continual evolution of technology have led ACOT staff to conclude that students and teachers need different kinds of technology for different purposes, and that they also need physical space for using other materials.

ACOT staff also initially assumed that the technology saturation, by itself, would spur dramatic changes in classroom practices. They found, however, that teachers tended to incorporate technology into their existing practices and styles. And they realized that it would require a fundamental cultural change to transform classrooms into environments where teachers facilitate student learning. As a consequence, ACOT staff provided new opportunities for teacher learning (with on-site expert help and intensive summer institutes) as well as opportunities for collaboration (with other educators and university researchers—in person and via electronic mail).

Investments and Benefits

Both the school districts and Apple fund technology and human resources, and these investments yield considerable benefits to both partners. For example Apple gets real-world laboratories in which to develop and test new knowledge about teaching and learning. And the school districts gain a cadre of teachers and students who are becoming national experts in teaching and learning with technology. The partners also benefit from the rich experience of a joint venture that has a strong commitment to strengthening education.

In addition, observations of ACOT classrooms demonstrate that major change has occurred at sites with several years' experience. The teachers and students are playing different roles, and there is more project work, more cooperative learning, more individualized attention, and more interdisciplinary activities.

Some Implications for Other Partnerships

Because of the classroom context and the research focus, the kinds of partnership represented by the ACOT sites are different from typical education-business

ACOT Report Summaries

partnerships. However, the ACOT experience suggests some important conditions that are necessary for the success of any education-business partnership.

- Partnerships must be based on shared goals and a frequently reaffirmed commitment from all levels of the school system.
- The business partner must demonstrate that self-interest does not override the goals of the partnership.
- The district partner must provide the conditions needed to nurture an experimental setting, and the openness to apply the lessons learned.
- Both partners must realize that partnerships created to affect teaching and learning require extra time for teachers—as well as intensive professional development.
- Innovations must mesh with existing organizational structures.
- Flexibility is key—for teachers to work together, to change schedules, to experiment, and for all sides of the partnership to learn and adapt continuously.
- Clear lines of communication are critical.

A Word About Communicating Findings

Research and development—on teaching and learning, on what it takes to change teaching practices, on uses of hardware and software, and on new forms of assessment—is becoming more important to school systems as efforts to restructure break new ground. Very little research and development occurs inside school systems, largely because there is no financial support, little flexibility to experiment, and no mechanism to learn from experience. ACOT demonstrates that corporations, in concert with educators, can make significant contribution in this arena.

To ensure that a small experimental effort has implications beyond the classroom walls, all parties must understand who needs what kind of information, and what form that information should take. Without extraordinary efforts on the part of local educators, policy makers, business partners, and researchers to communicate the findings in an ongoing fashion, the concept of research and development will not take hold in school systems.

More Information

The complete report is part of the ACOT Research Portfolio, a packet that includes five research reports, three information sheets, and a bibliography. The packet is available for $7.00 (plus shipping, handling, and applicable taxes) from the Apple Starting Line Program. Call 1-800-825-2145 to order by credit card or for information about using a purchase order. Request part number L0328LL/A.

You can also download the report from AppleLink. To find it, use the following path: K-12 Education: Education Resources: Apple Classrooms of Tomorrow/Learning Technologies: Research Reports.

Since its inception in 1985, the Apple Classrooms of Tomorrow (ACOT) project has examined the effects of immediate access to technology on teaching and learning.

In the ACOT research report summarized here, Cathy Ringstaff, Ph.D, and her colleagues discuss how the introduction of technology served as a catalyst for instructional change and led to major role shifts for both teachers and students. To get the complete report, see the information section at the end.

Trading Places: When Teachers Utilize Student Expertise in Technology-Intensive Classrooms

Background

In ACOT classrooms, teachers and students have constant access to a wide variety of technologies, including computers, printers, scanners, videodisc and videotape players, modems, CD-ROM drives, and hundreds of software titles. Data sources consisted of a variety of communications from 32 elementary and secondary teachers in ACOT classrooms: weekly reports sent via electronic mail, correspondence between sites, and bimonthly audio tapes on which the teachers reflected about their experiences. Using this self-report data, the researchers found that, at first, the teachers continued to rely on traditional teaching strategies—despite radical physical changes brought about by the introduction of the technological tools. Over time, however, the method of classroom instruction shifted from the traditional lecture-recitation-seatwork model to one that was heavily dependent on student collaboration and peer teaching.

This report provides an in-depth analysis of one aspect of instructional change—the willingness of teachers to relinquish their role as expert and to take advantage of student knowledge. The researchers examined how and why teachers began to utilize student expertise, how the roles of student experts expanded as teachers recognized the benefits of peer interaction, and how changes at the classroom and institutional levels reinforced teachers' decisions to utilize student expertise. Also, the report discusses the need for changes in teachers' and students' beliefs about their roles in the classroom. The researchers found that, as teachers experimented with new instructional strategies, they confronted their previous beliefs about the role of teacher and student.

This study differs from other investigations of peer collaboration because it focuses on the teachers' experiences and perspectives—rather than on student outcomes, and because it discusses how students went beyond peer teaching to share their expertise with teachers, school administrators, and family members. Also, since the data cover a five-year period, the report takes a long-term view of teacher change.

Using Students' Expertise

At the beginning of the project, teachers and students faced the daunting prospect of learning how to use a multitude of technological tools. In addition, most teachers felt uncomfortable with the fact that they knew little more than their students about using the technology. Before long, however, some students became experts in using particular computer software or hardware, and started providing technical assistance to one another and to their teachers. Even first-graders offered to teach their friends how to boot a disk or maneuver a mouse. At first,